BURN CARE AND REHABILITATION

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Survival rates for burn injury patients have increased significantly over the past several decades in the United States. Several factors have been cited for decreased mortality following burn injury, including the development of 150 burn units with 1700 specialized burn care beds. Additionally, improved understanding of the pathophysiology of burn injuries has led to major advances in volume resuscitation, antibiotic management, and skin grafting. Rehabilitation of burn-injured patient begins on the day of injury and may continue for years. A review of current rehabilitation practices in treating burn injuries is presented.

Burn injury occurs when the ability of the physiologic system to dissipate heat is overwhelmed. This leads to protein denaturation, coagulation, and cellular death. Cutaneous burn wounds can be classified as either partial thickness or full thickness injuries. Partial thickness burns may be superficial or deep injuries. Superficial partial thickness burns involve the epidermis and outer dermis, generally resulting in minimal physiologic and anatomic damage. Pain and erythema are major components of these injuries, which usually heal within 1-2 weeks. Deep partial thickness burn wounds involve injury to all surface epidermis and some portion of the deep dermis, leaving viable portions of epidermal skin appendages capable of re- epithelialization. In deep partial thickness burns, affected areas may be blistered, erythematous, moist, and blanch when touched. Full thickness burns involve complete destruction of both the epidermis and dermis. The wound generally has a white or black appearance, and is dry and anesthetic to touch. Full thickness wounds cannot re-epithelialize from epidermal remnants within the wound, and skin grafts may be required.[1]

Causative agents of burns include thermal, chemical, electrical, and radiation sources. The extent of the burn injury can be described by total body surface area burned (TBSA). A rule which may be helpful in quantitating small burns is that the patient's palm is approximately 1.0% of the total body surface area. To estimate TBSA, one may use the Rule of Nines developed by Pulaski and Tennison[1]. In this scheme, the body is represented by nines or multiples of nines, with the perineum comprising the final 1%. This method is particularly unreliable in children less than 15 years of age, in whom it underestimates the burn area of the head and neck, and overestimates the burn area of the legs. A more accurate estimation, developed by Lund and Browder in 1944,[2] accounts for changes in growth during childhood and adolescence.

ACUTE MANAGEMENT

Acute management of burn injury includes a thorough history and physical examination. The patient should be assessed for inhalation injury, concomitant skeletal or soft tissue trauma, and

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state of hydration. Various fluid resuscitation schemes have been devised as correction of electrolyte disturbances is essential. Hyponatremia, a frequent sequelae of fluid resuscitation, must be corrected slowly to prevent the complication of central pontine myelinosis.[3]

Immune defects have been identified in patients with major burn injuries, and the leading cause of death in the burn population remains infection. Except for gram positive organisms located in the depths of the sweat glands or hair follicles, the burn wound is initially free of major bacterial contamination. If topical antimicrobial agents are not used prophylactically to reduce the rate of bacterial proliferation, the wound may become colonized with millions of gram positive bacteria within the first 48 hours. Use of topical antimicrobials (e.g. silver sulfadiazine) has been shown to decrease mortality among patients with burns less than 40% TBSA. However, they have had little effect on mortality among patients with larger burns, particularly among those with more than 70% TBSA.[4]

WOUND MANAGEMENT

Burn wound management depends on the depth of the injury. Superficial partial thickness burns are usually allowed to re- epithelialize on their own.[5] However, a temporary closure with a biologic dressing may be used. Appropriate temporary skin substitutes include xenografts, allografts, cadaver skin, or the amnionic surface of the amnionic membrane. Concomitant immunosuppressant therapy may prolong graft survival.

Deep wounds (deep partial thickness and full thickness burns) do not heal efficaciously by re-epithelialization. Studies have shown that deep wounds heal best with early burn excision and wound closure.[5,6]

Permanent skin substitutes may be obtained from either a split thickness or full thickness autograft. Alternatively, permanent skin substitutes may be obtained from tissue cultures from either the patient or a skin donor. Sheets of human epidermal cells can be grown from cultures of human keratinocytes on a feeder layer of lethally irradiated mouse fibroblasts.[7] Unfortunately, cultured autografts require twenty-one days to produce once the skin sample is taken from the patient.[8]

Hydrotherapy techniques can be classified as either immersion or non-immersion. Non-immersion techniques involve placing the patient on a plinth which is angled over a Hubbard tank. A variety of spray or shower modes can then be used from this position. Immersion hydrotherapy in a Hubbard tank has been shown to increase the incidence of autocontamination of wounds, especially with GI flora and is therefore being discontinued at many centers in the U.S.[9,10]

POSITIONING

Therapeutic positioning is designed to induce edema resolution through elevation of the extremities; positioning also preserves function by promoting proper body alignment which helps prevent contractures. Prevention of other morbidity, especially localized compressive neuropathies, is also a primary goal of the positioning program. Table – 1 describes the proper body positions during periods of inactivity.[11]

TABLE – 1

Guidelines for Solving Common Problems in the Acute Phase[11]

Problem	Intervention
1. Anterior neck burns	1. Avoid pillows 2. Position in extension 3. Soft collar/watusi collar optional

2.	Ear burns	1. Position without pillows 2. Prevent lateral rotation with soft donut head support
3.	Mouth burns	1. Early exercise followed by mouth spreader
4.	Axillary burns	1. Position shoulder in 90° abduction with supination of the forearm and extension of elbow 2. Airplane splint
5.	Cubital fossa burns	1. Position elbow in extension and supination 2. Avoid medial elbow pressure 3. 3-point elbow extension splint
6.	Hand	1. Position in 30 degrees of wrist extension with 60 to 90 degrees of metacarpal-phalangeal joint flexion and full interphalangeal joint extension 2. Gauze roll
7.	Anterior chest burns	1. Position in shoulder abduction and external rotation 2. Small towel roll down midline of back 3. Avoid pillows
8.	Perineal burns	1. Position with 20 to 30° abduction hips 2. Avoid flexion and external rotation of hip 3. Soft foam positioning wedge
9.	Popliteal fossa burns	1. Position in full extension 2. 3-point knee extension splint
10.	Posterior calf and ankle	1. Position with foot board 2. Dorsiflexion splint
11.	Volar foot burns	1. Provide padded slippers 2. Encourage ambulation with elastic bandages in place
12.	Dorsal foot burn in children	1. High top shoes with optional conformer splint to position toes and ankle in plantar flexion
13.	Exposed tendons	1. Cover with moist gauze/biologic dressing 2. Splint in slack position; avoid exercise

SPLINTING

Splinting is an extension of the therapeutic positioning program. It is indicated when the patient is unable to voluntarily maintain proper positions, or is immobilized after surgical wound closure or grafting. Splinting may be initiated at any time during the acute burn period.[11]

Positioning and splinting of the hand is of paramount importance, given the functional implications of burn contractures of the hands. Without proper positioning, the hand assumes a position of deformity which is radial deviation with wrist flexion, metacarpal extension with hyperextension of the fourth and fifth metacarpophalangeal joints, and proximal and distal interphalangeal flexion (see Figure – 1). The longitudinal and palmar arches diminish, causing flattening of the palmar surface of the hand.[12]

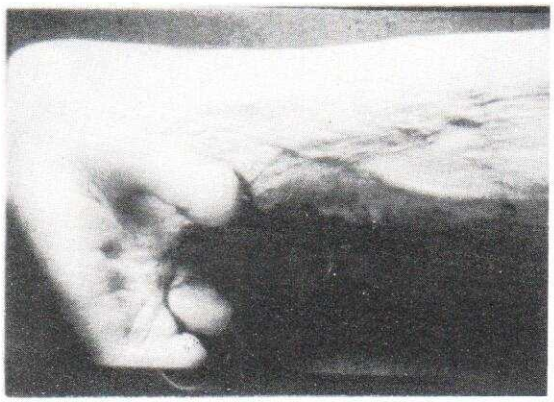

Fig. 1

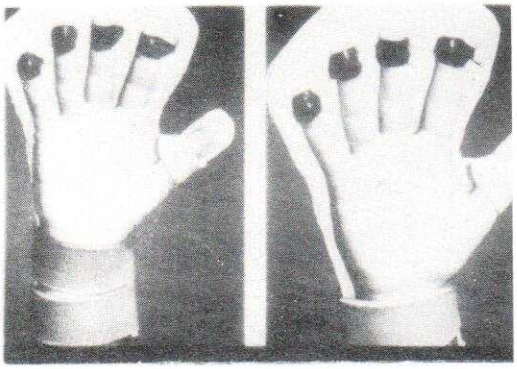

Fig. 2

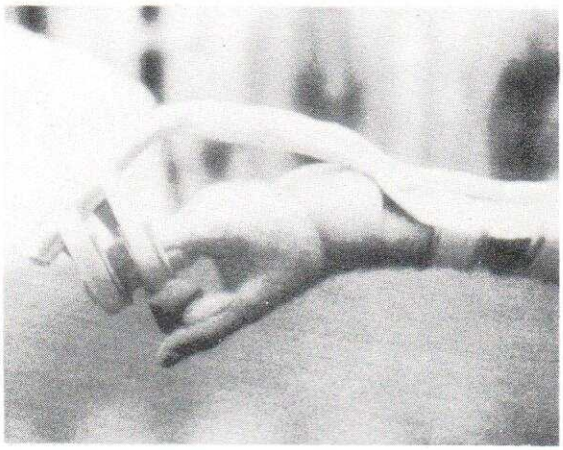

Fig. 3

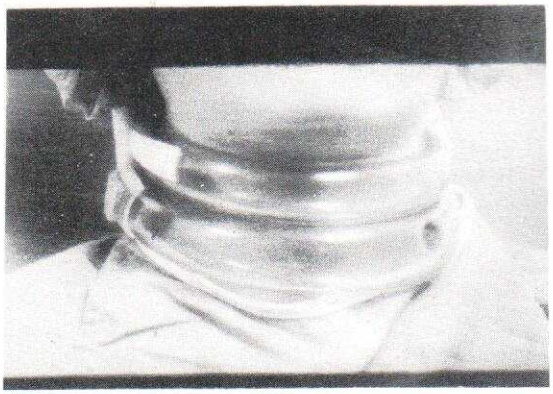

Fig. 4

Fig 5

FIGURES

Figure 1 – Severe head flexion contracture
Figure 2 – Dorsal hand orthosis used for palmar burn
Figure 3 – Dynamic wrist-hand orthosis allowing active distal phalangeal flexion
Figure 4 – Watusi collar
Figure 5 – Thermoplastic face mask

Dorsal hand burns occur twice as frequently as palmar hand burns because the dorsal skin is thinner. Dorsal skin elasticity allows the joints to move as the skin stretches and loss of this elasticity may cause a functional deficit. The proper position of the hand in dorsal skin burns is neutral wrist extension, metacarpal-phalangeal joint flexion between 60 and 90 degrees, and interphalangeal joint extension.[1,12] Extrinsic finger extensor tendons beneath the dorsal skin may be injured in dorsal hand burns. Injury to the central extensor mechanism may result in a Boutonniere deformity.[12]

The palm of the hand is covered by a very tough glabrous skin that is tethered to the underlying deep fascia. Palmar skin is usually spared in serious burn injury except in contact burns or large surface burns. The nine flexor tendons of the digits are usually protected by the thick palmar skin and fascia. The intrinsic hand muscles are rarely involved because of their depth. The proper position of the palmar burned hand is 30 degrees of wrist extension with 60 to 90 degrees of metacarpal- phalangeal joint flexion and full interphalangeal joint extension. The thumb should be positioned in abduction and opposition, with the arches of the hands preserved (see Figure 2). If the hand is too edematous for a splint initially, a gauze roll may be placed in the hand to maintain proper positioning.[1,13]

Dynamic splinting of the hand can be initiated as the wound begins to re-epithelialize. These splints are used when directional pull and stable static support are required. They can be somewhat cumbersome because, in addition to providing directional pull, they must accommodate dressings and wraps[1,13] (see Figure 3).

Splinting of the knee and elbow is accomplished via three point extension splints which maintain these joints in full extension. An airplane splint maintains the shoulder in 90 degrees of horizontal abduction to prevent the axillary web space from contracting. The ankles should be maintained at neutral dorsiflexion using a posterior splint.[1,2,13]

Anterior neck burns may be treated with a watusi collar which has rubber rings to prevent contracture (see Figure 4). Thermoplastic molded inserts can be added under the ring to concentrate pressure in specific burn areas.

PAIN

Pain managment in burn patients is of extreme importance for successful rehabilitation. Pain is severe in the acute phase; it may be described as throbbing, stinging, stabbing or lancinating. As the wound begins to heal, the pain lessens and is described as aching, burning and tender. Pain for burn patients does not necessarily end with the healing of their wounds. In rare cases causalgia, dysesthesia, and phantom pain syndrome have been reported to develop as late occurrence in burn wounds, especially when there is healing through granulation.

Pain management in the acute resuscitative phase (first 72 hours post injury) for patients with more than 20% TBSA may require opiates. Opiates help to manage the patient's pain, with little chance of respiratory depression. They may be given as continuous intravenous drip or as small frequent intravenous doses around the clock. Additional narcotics may be needed for painful procedures, e.g. dressings, exercise, etc.[14]

Standard narcotics may be considered later in the acute phase. Patient controlled analgesia (PCA) takes advantage of strong narcotics which can be self-administered in small frequent doese. PCA has been shown to effect pain relief with half the total doses, and fewer post-operative complications.[14] Nonsteroidal anti-inflammatory agents are also used alone or in combination with narcotics to treat pain in the acute phase.

Burn patients may continue to complain of pain during the late rehabilitative phase even if the wounds are closed. Itching and tingling can occur during scar maturation and the scar may be painful during exercise. Nonsteroidal anti-inflammatory drugs may be used during this time.

The patient may experience periods of depression and anxiety due to altered body image and restricted function, which may necessitate psychological intervention. Antidepressants and mild tranquilizers may help relieve the depression and anxiety.

EXERCISE PROGRAMS

An exercise program should be developed for the patient on the day of admission and should be started early in the rehabilitation process to prevent contractures (skin and joint), loss of muscle bulk, and respiratory complications. An exercise program is contraindicated when viability of the tissue is in question, or immediately after skin grafting. The exercise program is frequently initiated during hydrotherapy sessions and is limited to 20 minutes. Active exercises are usually initiated between five days and two weeks post-grafting. Active and active assistive exercises are most desirable. Passive range of motion is the least desirable exercise technique and is used only when the patient is noncompliant or cannot achieve full range of motion. Patients with superficial burns can participate in full, active ROM exercises. Pain control is a major issue during the exercise period and opioids are commonly used as a treatment.[14] As the patient improves, functional activities are added to the treatment scheme. Joint mobilization and stretching of scar contracture has an important role. However, caution must be used. Stretching should never be used on patients with exposed tendons or open joints. Care must be taken not to fracture recently healed fragile skin which will not tolerate stress and manual forces. Each burn patient should have a self-exercise program that he or she can perform in the absence of therapists, which begins with isometric exercises, and progresses to full joint range of motion against resistance.[7] The use of continuous passive motion machine (CPM) in the treatment of the burned hand is very helpful in maintaining ROM.

HYPERTROPHIC SCAR

Hypertrophic scarring and scar contractures are common sequelae of deep partial and full thickness thermal injury in which the reticular dermis is destroyed. Most superficial partial thickness burns heal without hypertrophic scarring. Clinically, the hypertrophic scar is red, raised, and rigid. It consists of an overgrowth of dermal components, often thickening to more than one centimeter with a thin atrophic epidermis. Hypertrophic scars may also occur at donor sites, precluding thermal trauma per se as the cause and suggesting an epidermal influence on dermal synthetic activity which is believed to result from overactive myofibroblasts.[15] The scar is often accompanied by a contracture which usually occurs on the flexor surfaces of joints, or where skin margins are unopposed by fixation points, e.g. eyelids, nares, lips. The scars will blanch, flatten, and soften with maturation. The end results of the hypertrophic scar are deformity, discomfort, and a less durable scar.[15]

Pressure is the standard method of preventing hypertrophic scar formation and accelerating its maturation. It is usually applied at 25 mm Hg or more (i.e. above capillary pressure) using a variety of materials including synthetic conformers and pressure garments. The pressure must be continuous and evenly applied for as long as the myofibroblasts remain active (usually six to twelve months). Many centers use a custom nylon elasticized garment such as a Jobst garment, because it provides enough pressure to prevent burn scar hypertrophy. Pressure therapy is believed to exert its effect via mechanical actions. One theory is that the pressure inhibits blood flow, which aggravates a pre- existent condition of vascular stasis and relative hypoxia and results in occlusion of the vessels in the scar. Another postulated effect of reduced blood flow is the inhibition of factors that impede scar breakdown.[15] The effects of pressure garment therapy include an immediate

superficial blancing and thinning.

Burn scar support garments can be further customized by the use of inserts and conformers which enhance pressure over problem areas such as the central face and the palm of the hand. These areas cannot be provided with adequate pressure by the pressure garment alone.[7] Some burn centers fabricate special plaster or thermoplastic face masks in an attempt to gain a better match of facial contours (see Figure 5). However, plaster and thermoplastics masks prevent dynamic facial movements. At present, elastic support face masks are the most commonly used.[16]

NEUROMUSCULAR COMPLICATIONS

Peripheral neuromuscular problems are common among thermally injured patients. Muscle weakness, all too often attributed to disuse, frequently prolongs and complicates the convalescent phase of burn treatment. A diffuse peripheral polyneuropathy of unknown etiology has been reported in 15 to 20% of burned patients, with a higher incidence among those patients with a TBSA of greater than 20%. Localized neuropathies secondary to compression or stretch are also a cause of muscle weakness and are usually avoided by proper positioning and splinting.5 There are numerous reports in the literature which document the prevalence of peripheral neuropathy in association with both electrical and non-electrical burns.[17] In a clinical and electromyographic study by Helm et al[18] which involved 88 burn patients with complaints of weakness or sensory loss, 84% had a total of 117 neuromuscular abnormalities. The most common diagnosis was generalized peripheral neuropathy (56%) which the authors felt to be secondary to burns over a large surface area, neurotoxic drugs, or some undetermined cause. Peripheral neuropathy was common in electric burn patients with less extensive burns. Hendersen[19] postulated that peripheral neuropathy in burn patients may be caused by metabolic disorders. In contrast, the Helm study found no statistical correlation between the occurrence of peripheral neuropathy and elevated blood urea nitrogen, sepsis, or the use of magnesium sulfate.[18] Neither study suggested a reason for the higher incidence of this disorder in electrical burn patients. Other late neurologic complications including seizures, headaches, paralysis, causalgia, radiculopathy, spastic paraplegia, spasticity, and myelopathy have been reported in these patients.

HETEROTOPIC OSSIFICATION

Deposition of calcium in the joint capsules causes heterotopic ossification and loss of range of motion of the affected joint. This phenomenon also occurs in a number of illnesses other than burns. The incidence is between 0.1% and 3.0% in burn patients, with the most involved joints being the elbow, shoulder, hip, and knee.

The cause of heterotopic ossification is unknown. Theories regarding etiology include overzealous joint manipulation, tissue hypoxia, local infection, circulatory stasis, immobilization, increased protein intake (greater than 150 g per day) with marked calciuresis, antigen-antibody disorders, and a possible neurotrophic factor.[20] Heterotopic bone appears to have a predisposition for the posteromedial aspect of the joints. Since injury with microhemorrhage caused by aggressive physical therapy is a postulated etiologic factor, once heterotopic ossification is diagnosed, patients should remain on an exercise program of active exercises only. Aggressive passive range of motion beyond the range of pain-free movements has been shown to result in complete ankylosis of the joint. Active range of motion exercises that maintain as much joint ROM as possible should be recommended.[21]

Cardinal warning signs of heterotopic ossification include a sudden decrease in range of motion, localized joint pain, progression to significant functional limitations, and positive confirmation by radiographs. Activity of heterotopic bone may be monitored by a triple

phase bone scan. Alkaline phosphatase is not a good indicator of heterotopic bone activity.[20] Etidronate disodium is a medication designed for prophylactic use, and may be of no benefit once heterotopic ossification has started.[20] Heterotopic bone, once formed, is allowed to mature for up to two years before a decision is made as to whether the patient will require surgical excision. However, this delay has been challenged recently. In addition, nerve entrapment has been considered by many to be a relative surgical emergency, and early resection of heterotopic bone in this setting is frequent.[22]

PSYCHOLOGY

Patients with burn injuries frequently have significant psychologic morbidity. An excellent descriptive study of the stages of adaptation following burn injury and a method of facilitating psychologic recovery was presented by Watkins.[23] However, a full discussion of the methods of psychological intervention cannot be undertaken here. Psychologic recovery after burn injury may require long-term intervention by psychologists, psychiatrists, and supportive personnel. This intervention is frequently one of the most important aspects of burn rehabilitation.

VOCATIONAL REHABILITATION

The ultimate goal of the burn team is to retrain hospitalized burn patients to their pre-injury level of function as soon as possible. Therefore, efforts should be spent not only on functional recovery, but also on vocational skills. This is especially significant since, except for children aged 1-5 who are scalded, the majority of burn victims are young men aged 17-30 years.[24] Burns are the third ranking cause of accidental injury.[25]

Emotional, social and physical issues have to be considered in prevocational counseling. Burn victims may lose their ability to feel secure and self confident at work, especially if they must return to an area where the injury occurred. Experience has shown that if injured workers do not return to work within 6-12 months, they may never return since nonfunctional habits, e.g. staying up late watching television and rising too late for work, depression, etc., become established. Work is important for physical and mental health of adults, and plans to return to work as soon as possible are important for complete rehabilitation. Burn injury patients often have decreased social contacts while recovering, and thus co-workers are encouraged to stay in touch. The patient may need to learn how to have a positive attitude to maintain social ties during their recovery.

Physical issues in vocational rehabilitation involve the presence of residual conditions, e.g. any open areas, joint contractures, residual pain, visual or hearing impairments, amputation(s), and memory or neurological dysfunction. A grotesque disfigurement of the face or hands may interfere with job function. Fear of returning to work may be another important issue. The employers may need to make work site accommodations and job modifications to allow the employee to return to their pre-burn position. Bowden[26] identified the following factors in 155 burn patients as being significant in influencing return to work : size and depth of burn, presence of hand burns, age of the patient, and type of work.

A controlled environment at the work site may be important, as some healed patients may not tolerate a dry environment while others may not tolerate high humidity. Some may never gain enough thermoregulation to tolerate heat above 70°F, Electric burns may cause permanent loss of sensation. Cataracts may also develop following electrical injury, with could impede vocational rehabilitation. A hearing aid should be provided if hearing loss is of recent origin. A patient with an inhalation injury may never regain full respiratory capacity. Neurological injury secondary to anoxia from inhalation may preclude return to pre- burn functional level.

A complete evaluation is needed so that adequate vocational guidance may be provided.

Flexibility of employers, creativity of the rehabilitation team, and motivation of the injured employee all contribute to successful vocational rehabilitation.

SUMMARY

Rehabilitation of the burn patient is an exciting, challenging, and rewarding process. These patients do benefit from a comprehensive rehabilitation approach.

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